Hints
ON
Steel.

ISSUED BY THE

CARPENTER STEEL COMPANY

Incorporated.

Works and General Office,

READING, PA.

Hints on Steel.

THE following suggestions are intended to convey to users and workers of steel some of the principles which govern the manufacturer that are usually shrouded in mystery, and to enable them to become better acquainted with the results which follow the several methods of working steel.

KINDS OF STEEL.

IT is not our intention to enter into a discussion of all kinds of steel—as that information is better obtained from books on the subject—but that you may distinguish true steel from the many steely or cold-short brittle irons called steel, made by the several methods of carbonizing, now being submitted to the public.

The majority of these come to grief as a commercial article, because of their nature, which is brittle, and have no body or toughness. They may harden well—so will pure cast-iron. They show the nature of steel, *but as good steel can only be made of pure refined material*, these fail because they are the product of cheaper processes of making iron.

Mixtures of irons well known to steel-makers are too often placed in market as new discoveries, which too soon tell their own story, and a good mechanic must have results.

We will confine our remarks principally to HIGH-GRADE STEEL, that being our specialty.

BLISTERED STEEL

Is the product made by placing wrought-iron bars in layers in an iron box, with charcoal or mixtures of charcoal and oily matters between the layers, then sealing up the box with clay and subjecting it to a cherry-red heat for hours or days, as may be deemed best, the iron becoming carbonized by absorbing the carbon of the charcoal. This kind of steel has an uncertain value, because the centres of the bars are too often soft and there are too many untreated spots occurring in them. Manufacturers of Crucible Steel use it to break up into melting pots, to shorten the operation of making Crucible Cast Steel.

BESSEMER STEEL

Is the product made by melting a suitable quality of pig-iron in a cupola, and while hot to be poured into a converter, which is furnished with a strong blast blown by powerful engines, the action of which separates the graphitic carbon and slags from the iron, leaving it comparatively pure and partially carbonized. By further treating it with an addition of spiegel containing manganese, the carbon is raised to the desired limit.

This kind of steel enters largely into commerce, as machinery steel, structural steel, rails, &c. Many

efforts are being made to re-work it with steel suitable for edge tools, and except for the cheapest kind of imitation it has not been successful. Reheating it and hammering it improves it by working in the latent carbons, and while some of it is occasionally used for tools, it has in all instances proved the labor on it to be more than its market value.

OPEN-HEARTH STEEL

Is the product made by melting mixtures of pig-iron and good steel, and sometimes with the addition of wrought-iron. This is melted and boiled at a high heat in a large furnace for several hours; manganese is then added until the mixture becomes carbonized to the desired temper, and then run into ingot molds.

This class of steel enters largely into use in manufactured goods of many descriptions, and the best quality is used for spiral springs, and here its usefulness seems to stop, waiting for scientific minds to develop it into higher use, as its present brittleness prevents it being used for edge tools, dies, cutlery, &c.

CRUCIBLE STEEL.

This kind of steel is commonly known as Pot Steel, because it is carbonized in crucibles, holding from sixty to eighty pounds each, placed in furnaces called pot-holes, and subjected to a very high heat, ranging

from 3500 to 4000 deg. F., for about four hours. If the operation consisted in only melting the puddled iron used, the operation could be completed in an hour, but it requires after melting a sufficient time to complete the chemical reactions, which gives the steel its wonderful toughness and tempering qualities.

The ores from which the iron is made must be carefully selected and scientifically reduced to cast-iron, with all the iron nature retained without impurities. This iron is then boiled in a puddling furnace, and all impurities and carbon worked out and slagged off, the ball is then formed, requiring to be treated so that no chill can form or any slag allowed to adhere to it, and then rolled into suitable bars for cutting up and filling the crucible.

The oldest practice extant causes these bars to be cemented or made into Blister Steel before charging into crucibles, but latter processes require mixtures of prepared steel and iron, with such additions and treatment as each manufacturer determines to be best for the qualities of steel he is making. These mixtures are almost numberless, and are secrets of the works using them. Hence each manufacturer has a line of custom which is more or less pleased with the product he sends them until they find a better.

CARBON IN STEEL.

We have only spoken of carbonizing in general terms, but as the carbonizing or giving temper to steel is an all-important subject to users of steel, we will mention the important relations it bears to the steel to be used. A common complaint is that steel contains hard and soft spots or layers, and these results are the effect of imperfect carbonization, and depend upon the skill and willingness of the manufacturer to incur the necessary expense in making, and an avoidance of all haste in securing results.

Carbon in steel is measured by points, the parts of one per cent., and the amount of carbon determines *the temper of the steel and the uses to which the steel may be put.* If all workers in steel heated and tempered steel alike, these tempers would become arbitrary, but as they do not, the temper or amount of carbon which suits one person perfectly does not suit the other. This is wrong, for the best efforts of the manufacturer are put forth to produce the best steel for the different fixed purposes, and workers in steel should endeavor to learn to adapt his heating, working, and hardening *to the nature of the steel* he is to use.

The following list of carbon tempers will illustrate our meaning and be a good general guide for the

user, often preventing him from using a steel unsuited by its nature for the intended work.

The lower the carbon, the tougher and more elastic steel will be when subjected to hard abuse or heavy blows. The higher in carbon, the more brittle it is, the higher cutting edge it will keep, but will not stand blows of a hammer, being less elastic and weaker in tensile strength.

CARBON TEMPERS.

Spring Steel.—.60 points carbon is used for strong springs for heavy weights.

.70 points carbon is used for clock and watch springs and light carriage springs—tempers blue.

Sett Steel.—.70 points carbon is used for sett chisels, and other cutting tools standing heavy hammering—tempers a bright blue or deep straw.

Die Steel.—.75 points carbon is used for dies which form hot-cutting or cold-pressing—tempers a deep straw color.

.80 point carbon is used for dies which do cold-cutting, punching files, &c.—tempers a deep straw to bright blue.

Cutlery Steel.—.90 points carbon is used for flat and spring knives—tempers fine and is elastic—tempers a bright blue.

Chisel Steel.—1.00 points carbon is used for cold chisels for cutting general iron work, stone, &c.—tempers a bright blue or deep straw.

1.10 points carbon is used for fine hard-chipping chisels on chilled castings, steel, granite, &c. Used also for spindles. Will not stand heavy blows. Tempers bright blue.

Tool Steel.—1.25 points carbon for lathe, planer, and machine tools—tempers a straw color.

1.35 points carbon. A special steel for chilled castings, does not need a high temper to stand well—tempers a bright blue or deep straw. Must be carefully treated.

Razor Steel.—1.50 points carbon used for razors and fine surgical instruments. Tempers a cat's-gray. Must be carefully handled.

Edge-Tool Steel.—1.00 to 1.50 points carbon used for carpenters and other fine edged tools, and varies according to the use it is put to—usually tempered blue to purple.

Self-Hardening Steel.—1.50 to 1.75 points carbon. This steel is used because it saves retempering, requires great care to save waste from overheating. It is tempered in a draught of air. If treated well it does marvelous work.

FORGING STEEL.

A difference in carbon in steel *makes a difference in the heat* at which steel may be worked. The range of colors varies from a black heat to red heat.

The average color for working Chisel and Tool Steels is cherry red, and Hard-Tool Steel not above a red heat. What a Chisel Steel *would stand easily would burn* Tool Steel and cause it to crumble. Although very sensitive to heat, steel will bear more forging than iron if not overheated.

In forging steel, use a good-sized hand-hammer with rapid strokes, and the steel will forge much easier than with a sledge and with heavy blows.

Overheating, remember, *is injurious to steel*, and while you may succeed in forging the piece, the tools made will not wear half so well as when the forging is done at as low a heat as possible. The steel-maker uses the greatest care to compact and toughen the steel by rolling and hammering at great expense, and as overheating expands the steel and opens the grain, it stands to reason that his labor is thrown away and the compactness lost when it is overheated. All steel should be heated slowly by soaking; the blast should be avoided; the steel should be turned often, and kept at a uniform color while forging. A brick or a piece of iron placed over the fire is a great assistance in giving steel a proper heating.

When steel has been forged to shape, it should be allowed to cool slowly *until cold*, and if to be machine-cut before using, they should be annealed in a box of ashes or a mixture of lime and charcoal.

It is absolutely necessary to select the proper steel adapted to the intended purposes.

WELDING STEEL.

There is no difficulty in welding Natural or Blister Steel, but with Crucible Steel the case is different. Two pieces of this steel can be easily welded together, or welded to iron, if proper care is used.

It is necessary to use a flux, and a mixture of calcined borax and potters' clay is used in equal proportions. Calcine the borax by placing it in an iron pot over the fire until the water is evaporated off and the residue melts into a glassy substance, then mix this thoroughly with the clay. The object in using a flux is that it will melt and form a glassy surface on the steel scarfing to prevent the forming of oxide, which hinders it from welding. Watch the flux to see that it does not burn off, and then the heat being *a proper orange color*, the steel will make a good weld.

Heavy pressure or a rapid stroke of the hammer is all that is needed to cause proper cohesion.

HARDENING AND TEMPERING STEEL.

If steel will not bear a great heat in forging, *it will not stand it for hardening.* If hardened above a cherry red, steel becomes too brittle, and loses all its toughness, caused by the unnecessary expansion of the steel, which opens the grain, and when suddenly cooled off, the particles become separated and glassy.

The cohesion of steel when hardening is increased only when the steel is hardened at a low heat.

Hardening steel requires good judgment. The proper method of preparing steel is to expose *only that portion of the steel* to the fire which requires hardening, remembering that wherever the heat goes, the hardening will follow in good steel, and then tempering the steel by drawing it with a hot iron to the proper color afterwards.

A good method is to lay a bar of cold iron across the bottom of the fire, and another piece over, with just sufficient space to admit the tool; then when to a low red immerse it in clear water with the cold chill taken off. This method insures the steel retaining all its strength and toughness behind the hardened part, preventing fractured tools, which are a constant worry to a careless tool-dresser.

The expansion of hardened steel is a great inconvenience to workmen, and good steel for good tools and good work is essential.

In hardening steel it is essential to heat to the point which gives the greatest hardness, and it is more essential that the temperature of the cooling fluids be proper. If the steel is heated properly, the degree of hardness is better regulated by the choosing of more or less cold fluids, as different carbons of steel show different colors at the same heat. The heat that hardens one kind hard would make another too soft.

Hard well or spring water is the best to use for tempering. Some use salt in addition, while others use clay and salt. If these are properly used as experience will dictate, there are no other mixtures which can excel them. The use of oil for thin blades requiring elasticity is proper and good in its place.

For hardening large objects a current of water is necessary. Proper tempering can only be learned by learning the working qualities of different tempers on the work to be done. A tool often tempered to one piece of work will not do another piece.

Hardening in oil is of value when the carbon is higher than that required to suit the purpose for which the steel is intended.

If the edge of a cutting tool granulates, it is evidence that it has been overheated; if it drifts, then it requires to be hardened more.

If a steel does not give its best results on a first trial,

try it again. It will be a saving of time and money to find out the best results.

A tool-dresser should watch the work done with the tools he makes.

HOW TO TELL GOOD STEEL.

This is of great importance to steel-workers, and the part of their education which is sadly neglected.

The fracture of the bar should show a uniform good gray color, inclined to be bluish, with a ragged tearing, which leaves sharp fine points; and if the steel is of fine quality and pure metal, it will show a silvery blue blush, which is but rarely found in steels furnished in the open market. A short dry fracture, white in appearance, indicates a brittle steel which will not wear well.

Bright silvery grains, with round-looking heads shining like diamonds, indicates the steel to be raw and improperly made.

A soft hard steel is the climax of good quality, which means that it *works soft* under the hammer and *hardens* with a fine temper. The best steels will harden well, and cut glass or a file easily, and a fracture of the hardened part shows a clear, blue silver white.

Good steel when worked will show a smooth fine

surface, close and shiny, with a fine bluish lustre, without pin-holes, cracks, or streaks of whitish color.

When machine-dressed, the surface will be of even color and texture, and entirely free from dark and white colorings, as though marked with black oily fingers. When ground it is hard, but catches the grit of the grindstone evenly. When polished it has a fine high lustre of a looking-glass.

HOW TO TEST STEEL.

The surest test of the quality of steel is to draw it down to tapered point, harden it, and try the strength by breaking it with a hammer (the blow being light), and the degree of force required determining its quality, or secure the hardened point in a vise and try its strength. A trial will demonstrate the value of this test and be of value to the user.

Cutlery Steel, when sharpened, should cut the finest kind of shavings from a piece of soft pine wood without marring the surface. Try your knife on a hone; if it grinds without burning, you know it is an extra fine piece of steel.

If a chisel will upset behind the tempered point under heavy blows, it is evidence of superior toughness.

MAKING STEEL DIES.

The selection of steel for dies is an important one. The manufacturer must use the best materials and of remarkable toughness, and of good tempering quality, free from veins, pin-holes, and show of clear even color when planed, free from all discolorations.

The steel when cut to shape should then be examined with a lens for ash-streaks, which are almost invisible, and one of the causes of steel cracking.

If the die is a costly one, the steel selected should be washed with diluted *aqua fortis*, which will show these streaks and the damask veins of the steel. If the steel is all right, the grain of the surface will appear close, fine, perfectly uniform, and clear in color.

Steel for stamping dies should be softer than steel for cutting dies, as a die which would cut perfectly will crush if used for stamping. So, also, there is a difference in cold and hot cutting steel, which should be noted by the manufacturer. One who makes Die Steel a special study soon becomes aware of this difference.

Die Steel is made at a low specific heat, therefore the die-worker should use only a low heat, and exercise great patience in developing the hardening and temper.

A makeshift way of working and neglect not only

destroys the value of a die, but often spoils the steel, causing cracks from unequal expansion and contraction. Very much depends on the die-worker, his keen appreciation of the proper heat, which should be the lowest possible, and his care to avoid overheating or of heating too often.

After the forging is complete, Die Steel should be annealed, and a good way to do is to imbed the steel in coarse charcoal powder in a crucible, then heat it to a cherry red, then imbed the crucible in ashes and let it cool very slowly. This should be particularly well done if the steel is to be engraved or very fine cutting points made in it. A low heat lasting 24 hours is none too long for proper annealing. When ready to harden, heat the steel slowly in a crucible in charcoal; and as the steel is injured by rehardening, the heat selected should be that which will give it the hardest temper required, which is easily determined by trying a piece off the same bar. Then the hardening is best done in clear running water. It will now become apparent to the operator that steel takes different degrees of hardness under the same treatment, which will clearly show him that he must know the carbon temper of the steel he is using, and select that which is best suited for his purpose.

A number of methods are resorted to by die-makers to avoid cracking steel, but we know none better than

the proper selection of steel to begin with, and the careful avoidance of overheating.

A good custom is to boil a die in water for several hours, and let it cool off in the water, as it toughens the die by relieving it of the overstraining of any part caused by contraction.

A pure ductile steel is not liable to shrinkage, and is therefore free from cracking; and if selected as we have mentioned, the danger will very often be avoided.

Tempering dies can be well done in a pan of heated sand.

Remember that the slower all heating is done, either for forging, annealing, hardening, or tempering, the better the die will be.

PRICES.

We have found it impossible to manufacture the quality and character of the steel required by our customers at ruling prices of cheap steel, or at the same prices of some English or other foreign steels, and we do not desire to compete with cheap grades of steel.

Our steel is SPECIAL, and as such it is cheaper than any steel furnished in this market. It is so far superior to so-called cheap steels, *in the quality and amount of work done,* that it is far cheaper than any of them.

It is cheaper in cost than *special imported* or *domestic steels,* and it rivals the *best brands* in results, which is of far greater importance.

Our steel will be sent at our expense, on an order from you, *on approval*: if satisfactory, we expect a fair price for it; if not, you will please return the steel at our expense, and OWE US NOTHING for what you may have used in trying it.

We will always appreciate a customer sending us a condemned tool, if he has one, that we may know why it was rejected. Be sure *to try it twice* before sending it back, *as overheating* may be the trouble with it.

OUR MILLS.

The mill buildings are large and roomy; the rolling-mills are the finest known, made with all improvements, giving strength and accuracy in rolling, each and every mill running with separate engines, and so arranged as to do the work well and economically to fine gauges.

Furnaces for refining, heating, and carbonizing steel are of the best patterns, and working perfectly, so that bars of steel of the largest and the very smallest sizes can be rolled at will.

Steam-hammers varying from 400 pounds weight to ten tons have been erected, and are of the best makes known for the proper tilting of steel.

Our storerooms are large and ample for necessary stock to keep ready for orders.

Machine and other shops fully equipped for work; a cold-rolling-mill is being finished to meet trade requirements, so that the equipment is second to none of any known steel works.

All stock is carefully examined, analyzed, and tested during all stages from the raw material to the finished product.

The Carpenter Steel Company,

INCORPORATED,

Was organized in New York city, where it has its principal office; also in Jersey City, N. J.

The Works and General Office are located at Reading, Berks County, Pennsylvania.

For some years the experiments were carried on, to see if fine steels could be made to meet the rising demands for fine steels in this country; and when successfully demonstrated, a temporary works were secured and a test made on a large scale, costing many thousand dollars.

The steels manufactured were sold on approval, at almost any price users of steel would pay, until the commercial value of the steel was fully assured; then sufficient capital was invested to make it a strong financial company, composed of gentlemen of means in New York, Philadelphia, and other cities, and our new Works at Reading were built and equipped to meet the growing demand for this steel.

All the promises made by mechanics and users of steel have been fully kept, and they have made a success of our enterprise by patiently trying specimen bars to test their value, and responded handsomely by ordering their supplies from us.

REMARKS OF MECHANICS.

"We prefer your Cutlery Steel to any we have used from Sheffield during forty years' experience."

"Your Tool Steel has cut steel shafting from 20 to 30 hours without resharpening."

"Your Tool Steel cut chilled castings when all other steel failed."

"Your Special Steel cut chilled charcoal-iron rolls, too hard for a file to touch, from five to seven hours without resharpening."

"Your Chisel Steel chipped steel castings four to one better than any other steel.

"Our stone drills, of your steel, cut through flint rock without losing the edge or points, when our other drills must be repaired frequently and do not stand."

"Two Carpenter Steel points does the work of ten other points on sandstone."

"The Die Steel you furnished does not crack or drift. I have worn out five dies of English steel to one of yours."

"We can work your Die Steel into every kind we use, and have had no cracked pieces or failures."

"Every blacksmith says the steel forges soft as iron, and tempers to a hard strong edge."

GENERAL REMARKS.

With the foregoing remarks we might close, but as you may be interested in knowing about steel-making, and why all steel is not what it seems and what steel should be, we hope to make the following an interesting source of information.

In former years, the history of the world tells us, steel has been made which surpasses all comparison with the present article. This is undoubtedly true, for the treatment of ores took a long time before being converted into iron. All the heating required afterwards being done by charcoal fires and hand-blowers on small lumps, and the reworkings were slow and laborious; and we discover that the slower methods of working iron into steel are producing the better article.

In later years, the introduction of furnaces, working large masses with the assistance of machinery, has made steels of poorer variety, while they have served the world well by producing so-called steels which have not needed to be of the highest grade, and with them filled places which needed a superior article to iron. With these we have nothing to do in this article, our object being to illustrate the subject of fine HIGH-GRADE STEELS. The methods in this have been considerably shortened, but very little though; for we must still refine the ores and the irons by first

smelting them, and then removing the impurities by boiling, working, and reheating them until we obtain pure iron; and then afterwards melting them in crucibles in strong blast-furnaces at proper heat until the chemical reactions take place which discharge the gaseous impurities left and form good steel, which must then be worked, reheated, hammered, &c., until the proper developments are made and the metal compacted ready to do the work required. All this is shorter than the past methods somewhat; but if quality is required, the time and expense amounts to a large investment.

The practical difficulties of making good steel are many, and good results are often impossible. In making steel of refined iron, if too much carbon be used it makes cast-iron, if too little we simply have wrought-iron. If the mixtures be correct and the heat too great, the steel is ruined by burning; if too little, it does not make steel that is worth using; and each step afterwards makes or ruins the product before it is finished. Therefore the labor employed must be skillful, well paid, and be men of educated judgment.

The rise of competition among steel-makers has caused them to deteriorate the qualities of the product by shortening their methods, and making use of such material as will cheapen the cost, and thus be enabled to get the market; and the users of steel must bear

the burden of the losses of time and money spent on the inferior steels.

It is a common mistake to suppose that any iron which will temper is steel; also to suppose irons which are hard and will make a cutting edge is good steel. This is not so. Cast-iron of some varieties can be made to take temper; cold-short wrought-iron will take temper; almost any alloy with iron will take temper, the hardening of copper being no longer a mystery.

Almost any metal can be hardened to cut other metals. If this be so, it is easy to see that many so-called new discoveries are not what they claim to be, as will easily be discovered when the mechanic puts them to the test. The edges fly and crack; they don't forge the second time without discovering their value; and that such material which gives such results can be mixed with good iron again, and then be called good steel, is preposterous.

We can only repeat, it takes *pure materials to make pure steel*, and *one good steel tool is worth a dozen poor ones*. The labor spent and wasted on poor steel would make many mechanics rich, and the way to find it out is to try a piece of good steel, treat it properly, and when the tool gets its work in, it is very easy to see the difference.

So many have so often said to us, "We will give

any price for steel which will stand our work." Die-makers beg for a steel which "will not crack in hardening." Mechanics ask for good chisels, barbers for good razors, wood-workers for good tools, every man and boy for a good knife, and so on *ad infinitum*, until it seems that there can be little, if any, good steel to be had.

England has been pre-eminent in furnishing good steels for many years, and has good iron from Sweden to make steel with. Much fault is found with that which reaches this country, and why?

America has irons which will make Swedish iron, but they are not to be found in the market; makers of steel in America buy Swedish irons. But good steels are made in this country, as good as England makes, of American irons. The cheapening of steel here has created a prejudice in favor of the English article, because our manufacturers take means to cheapen the cost, too often at the expense of quality.

We have concluded, therefore, *that we would meet the demand for good steel, we would refine our own irons, make our steel under the best methods, either new or old, sparing no expense or labor in accomplishing the results.* That we have met with encouragement, and that our American people appreciate a good steel even if made in America, is attested by the many testimonials of approval and the growing size of the orders for this steel.